Introduction to Botany. Lecture 17

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Outline

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Previous final question: the answer

Please invent a multiple choice test question for the second exam
(**subject**: root, stem or leaf).
There should be at least **three** exclusive choices.

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10 questions went to the exam!

Green slugs

Green *Hydra*

van Helmont

- Johannes van Helmont (17th century) rejected the idea that plans take most of their biomass from soil
- Willow (*Salix* sp.) tree of 2.27 kg grew to 67.7 kg in five years, but weight of soil decreased only by 57 g
- van Helmont concluded that plants take most of their weight from water

Pristley

- Famous Joseph Pristley in 1772, made series of experiments with mouse, candle and sprig of mint (*Mentha* sp.)
- Mouse behave similar to candle, they both “spent” air
- Plant revives the air for both candle and mouse

Further history

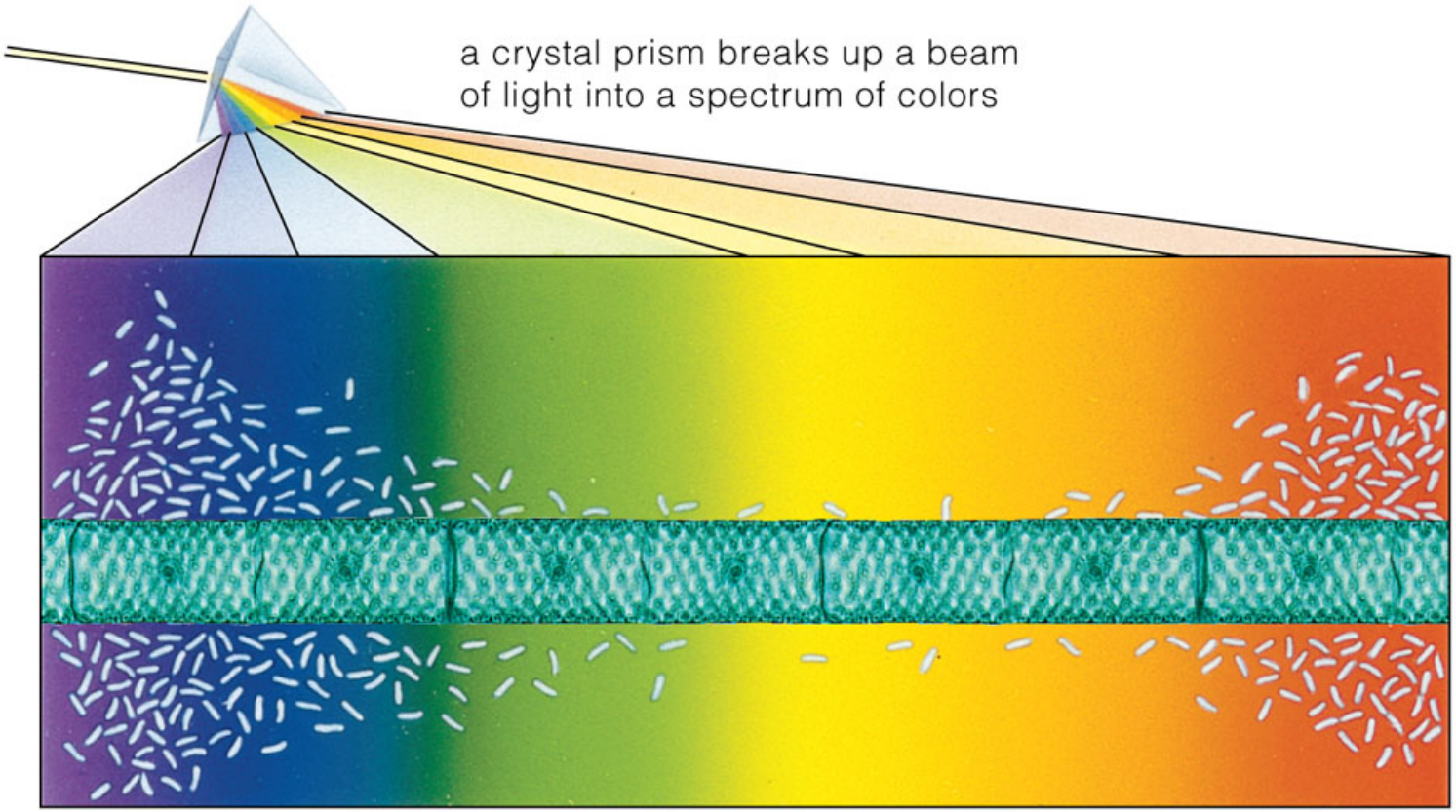
J. Ingen-Houst (1779–1796) and J. Senebier (1780) found that:

- “Experiments upon vegetables, discovering their great power of purifying the common air in the sunshine and of injuring it in the shade and at night, to which is joined a new method of examining the accurate degree of the atmosphere”
- CO_2 is assembled

Engelmann

- T.W. Engelmann in 1884 found that *Spirogyra* alga produce oxygen mostly in blue and red parts of spectrum
- Therefore, the key photosynthetic pigment should accept blue and red rays and reflect green rays
- Chlorophyll fits best to this description

Experiment of Engelmann



Blackman

- In 1905, F.F. Blackman discovered that if light intensity is low, increase of temperature has a little effect on the rate if photosynthesis
- Consequently, photosynthesis has two stages:
  1. Light stage which relates more with light intetsity
  2. “Dark” (now called *enzymatic* or *light-independent*) stage which relates more with temperature

Light and enzymatic (“dark”) reactions

- Light reactions depend on the light and water, they produce oxygen and energy (in form of ATP)
- Enzymatic reactions depend on carbon dioxide and water, they take energy from light reactions and result in production of carbohydrates
- Main component of enzymatic reactions called Calvin cycle which fixates carbon dioxide

Equation

- $6CO_2 + 6H_2O \xrightarrow{light} C_6H_{12}0_6 + 6O_2$ is not a formula, but merely a general description of a process
- Water molecules arise from both sides, and the better formula is

  $6CO_2 + 12H_2O \xrightarrow{light} C_6H_{12}0_6 + 6H_20 + 6O_2$

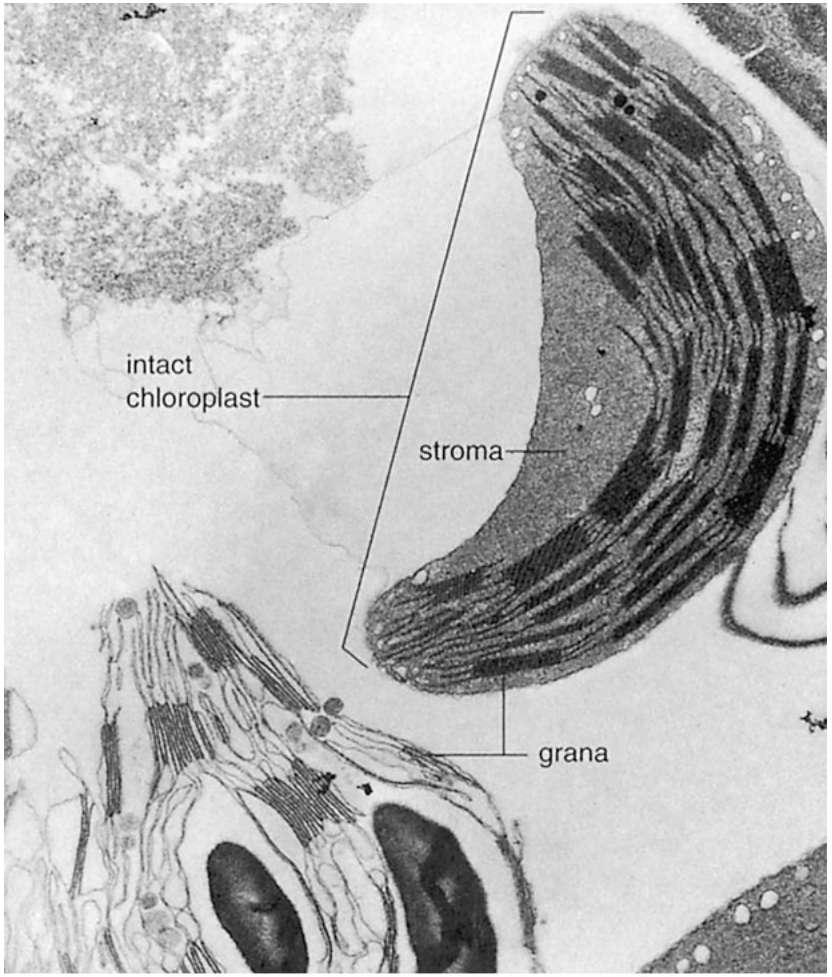
  or even

  carbon dioxide + hydrogen donor $\xrightarrow{light}$ carbohydrate + water + oxidized hydrogen donor

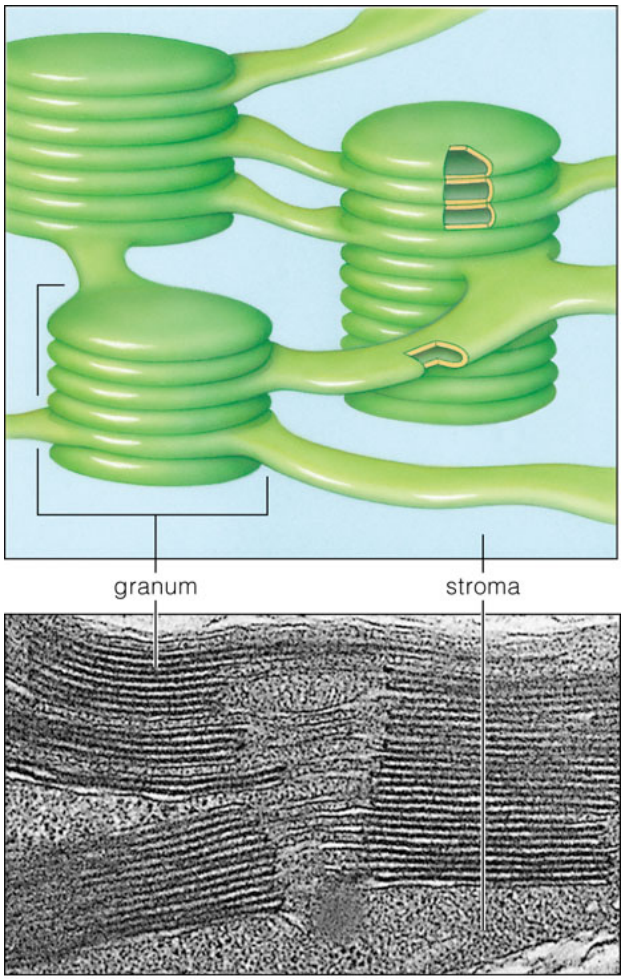
Compartments of chloroplast

- Even isolated chloroplasts may take light and fixate carbon dioxide
- Photosynthesis is related with membrane system (tylacoids) of chloroplasts, which has two parts:
  1. grana
  2. stroma lamellum

Stroma



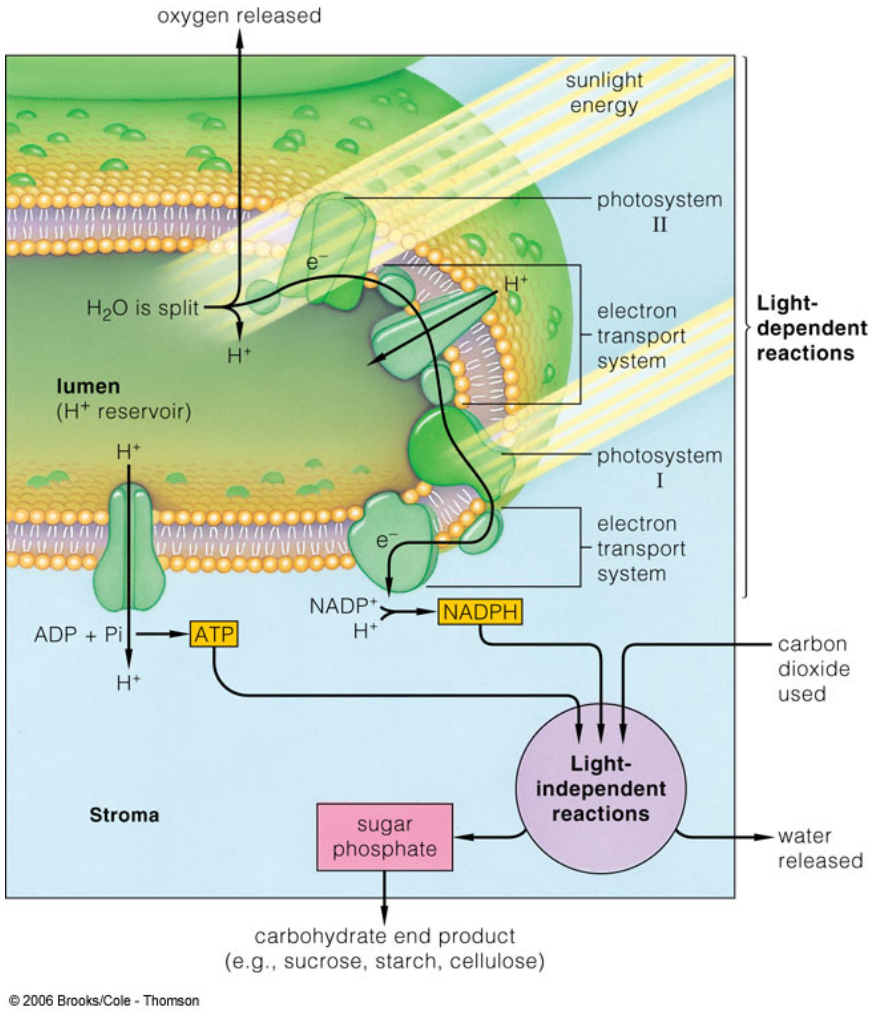
Tylacoids



Division of labor in chloroplast

- Light reactions are concentrated around tylacoid membranes, tylacoids are also H^+ (protons, hydrogen ions) reservoir
- Enzymatic reactions run in stroma (chloroplast "cytoplasm")

Location of two stages



Participants of light stage

1. Chlorophyll
2. Light
3. Water
4. ATP synthase
5. Protons (H^+)
6. Hydrogen carrier ($NADP^+$)
7. **Place**: around tylacoid membrane

Main events of light stage

1. Chlorophyll + Light $\longrightarrow$ Electron (e^-) + Chlorophyll$^+$
2. $H_2O \longrightarrow H^+ + OH^-$ (accumulates outside)
3. $e^- + H^+$ + Hydrogen carrier ($NADP^+$) $\longrightarrow$ NADPH (moves away)
4. $H_2O \longrightarrow H^+$ (accumulates inside) + e^- + O_2
5. H^+ (inside) + OH^- (outside) $\longrightarrow$ gradient $\longrightarrow$ PROTON PUMP $\longrightarrow$ ADP + P_i (inorganic phosphate) $\longrightarrow$ ATP

Summary

- From 17th century, in constantly become clear that plants make their biomass from light, water and carbon dioxide
- **Photosynthesis** is a sum of light-dependent and light-independent reactions
- Light reactions are concentrated around **tylacoid membrane** whereas enzymatic reactions concentrate in **stroma**

Final question (2 points)

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Which conclusions can be drawn from Pristley's experiments?
Please list more than one.

For Further Reading

J. E. Bidlack, Sh. H. Jansky.
Stern's introductory plant biology. 12th edition.
McGraw-Hill, 2011.
Chapter 10.

Th. L. Rost, M. G. Barbour, C. R. Stocking, T. M. Murphy.
Plant Biology. 2nd edition.
Thomson Brooks/Cole, 2006.
Chapter 10.